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Watanabe

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(54) **LIGHT GENERATING UNIT AND APPARATUS EQUIPPED WITH A PLURALITY OF LIGHT GENERATING UNITS**

(75) Inventor: **Masaru Watanabe**, Tokyo (JP)

(73) Assignee: **Lapin Create, Inc.**, Nerima-Ku, Tokyo (JP)

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G09F 13/24	(2006.01)
F21S 10/00	(2006.01)
F21V 9/12	(2006.01)

(52) **U.S. Cl.**

CPC ***G09F 13/24*** (2013.01); ***F21S 10/002*** (2013.01); *F21V 9/12* (2013.01)
USPC **362/101**; 362/96; 40/406; 40/407; 40/439

(58) **Field of Classification Search**

CPC G09F 13/24; F21S 10/002; F21V 9/12
USPC 362/101, 96; 40/406, 407, 439–441
See application file for complete search history.

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Primary Examiner — David J Makiya
(74) *Attorney, Agent, or Firm* — Buchanan Ingersoll & Rooney PC

(57) **ABSTRACT**

There is provided a light generating unit including a transparent vessel that is elongated and contains water and a light-emitting/bubble producing unit that is attached to a base plate of the vessel. The light-emitting/bubble producing unit includes a plurality of LEDs arranged around inner surfaces of side walls of the vessel and a plurality of nozzles for discharging gas that are disposed on an inside of the plurality of LEDs. Also provided is a display apparatus in which a plurality of the light generating units are arranged with the vessels adjacent to one another so as to construct a light generating block in the shape of a wall and which is capable of displaying images and/or information by way of bubbles and illumination light.

9 Claims, 6 Drawing Sheets

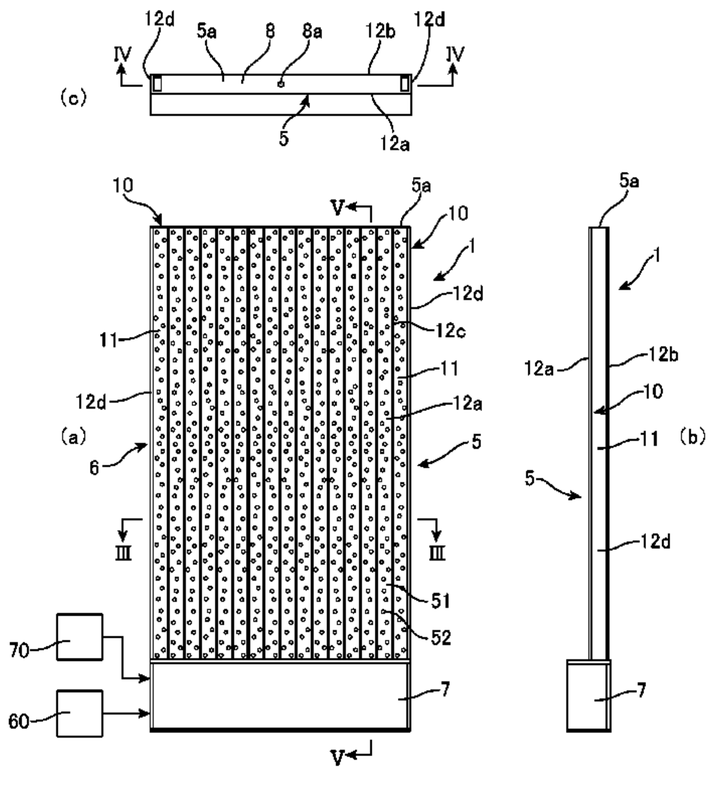

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Fig. 1

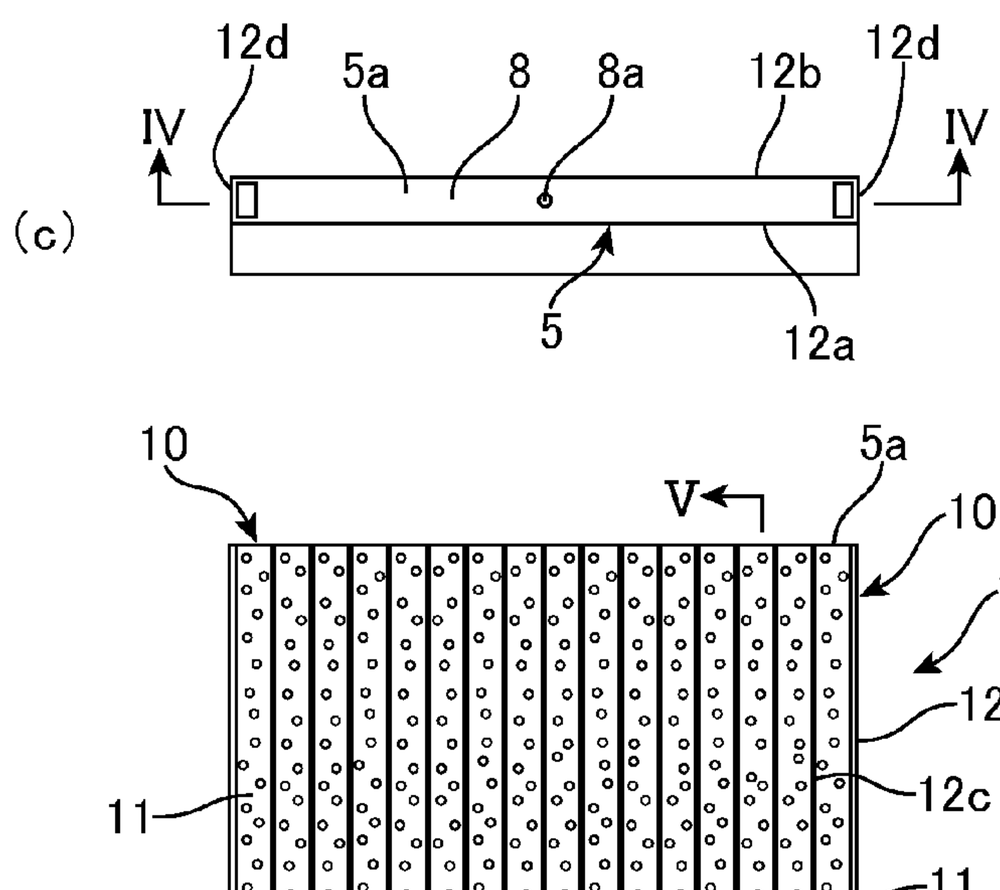

12d
5a
8
8a
12b
12d
IV
IV
(c)
5
12a
10
V
5a
10
1
12d
12c
11
11
12d
12a
(a)
6
5
III
III
51
52
70
7
60
V
5a
1
12a
12b
10
11
(b)
5
12d
7

Fig. 2

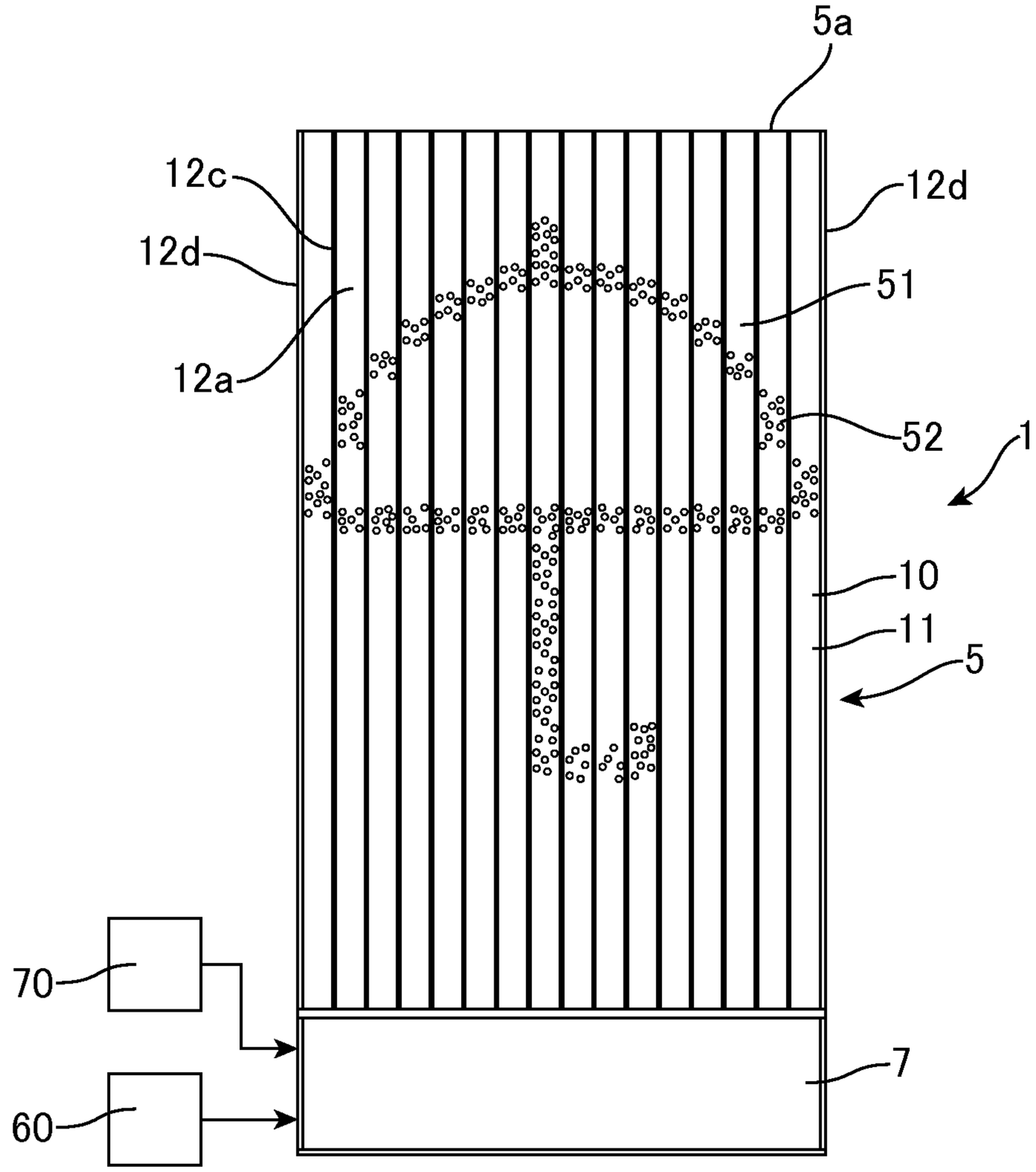


Fig. 3

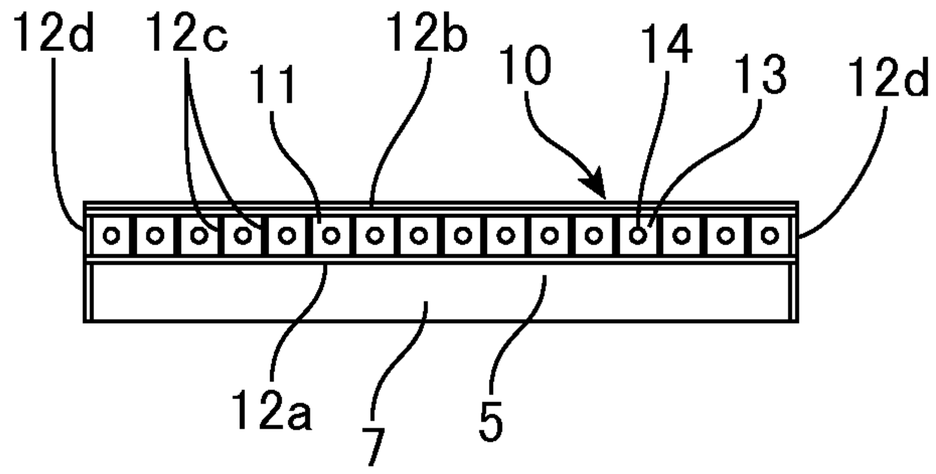
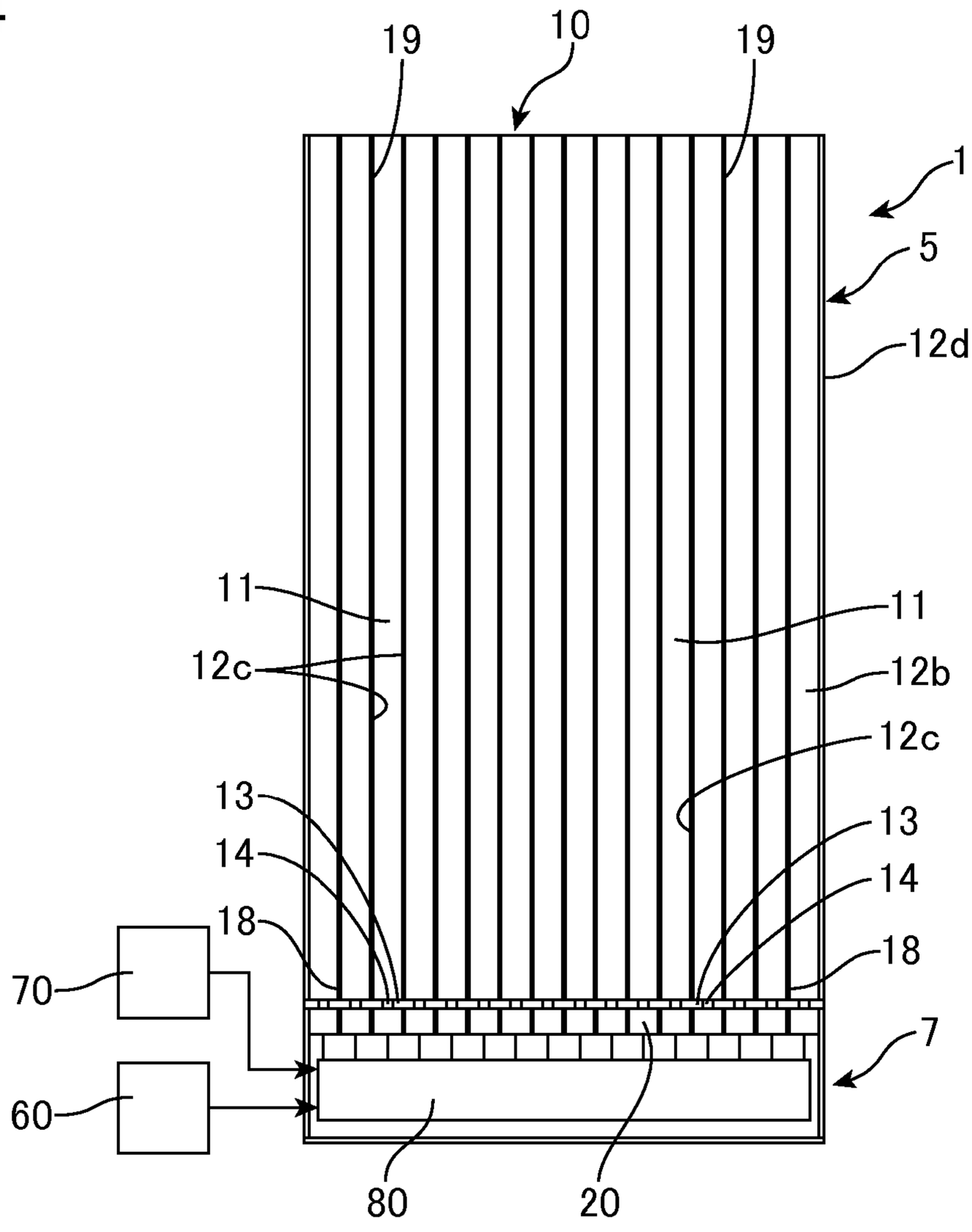

12d
12c
11
12b
10
14
13
12d
12a
7
5

Fig. 4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10
19
1
5
12d
11
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12c
12b
12c
13
14
18
13
14
18
70
60
7
80
20

Fig. 5

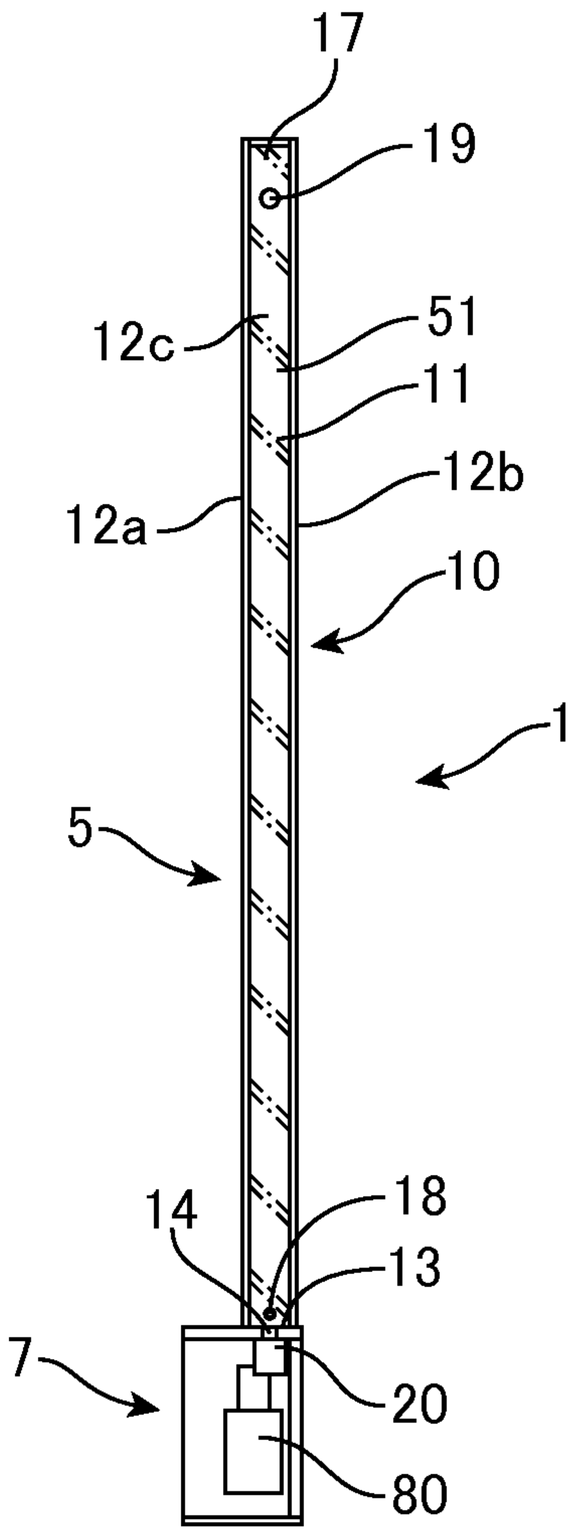


Fig. 6

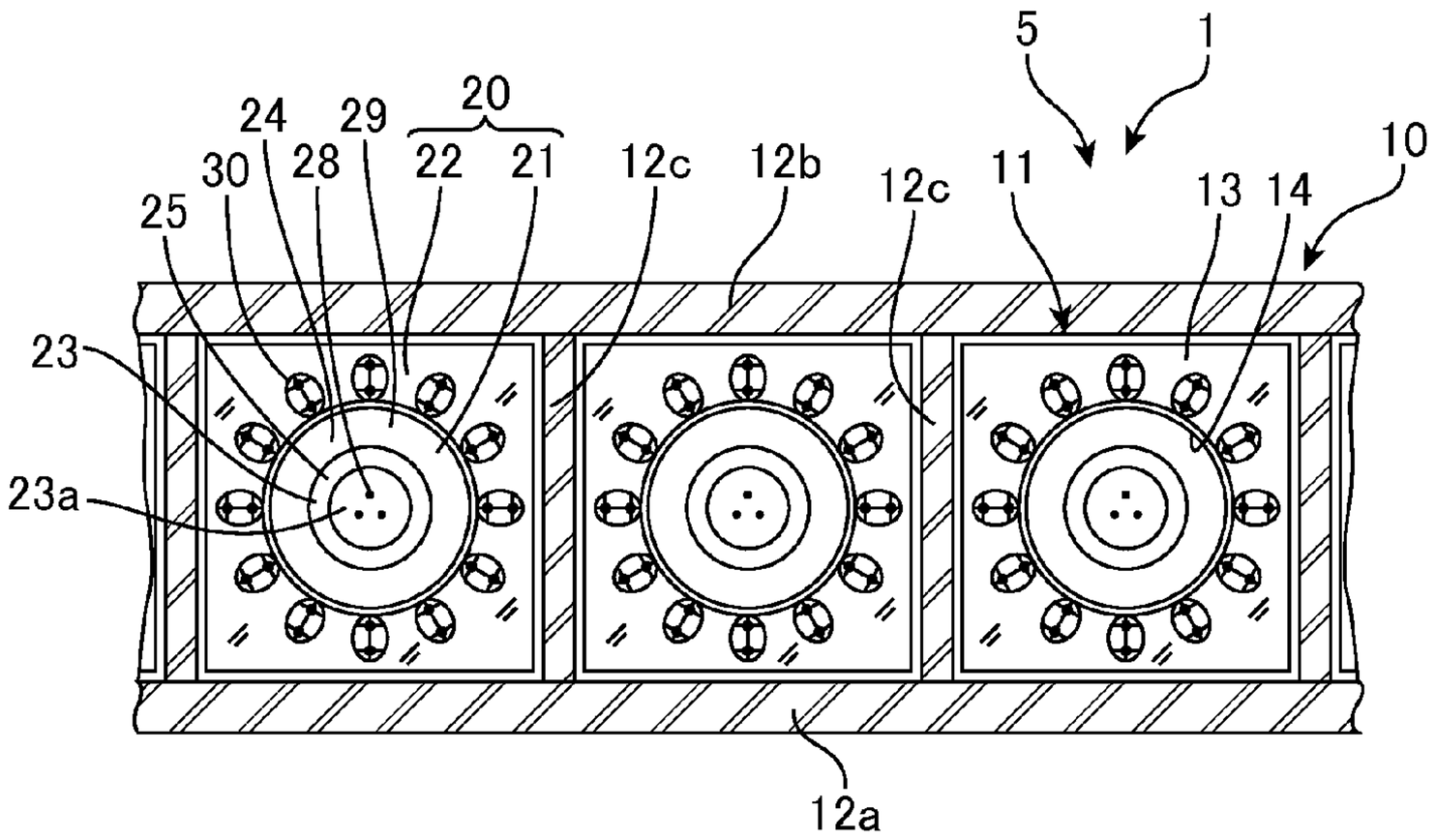
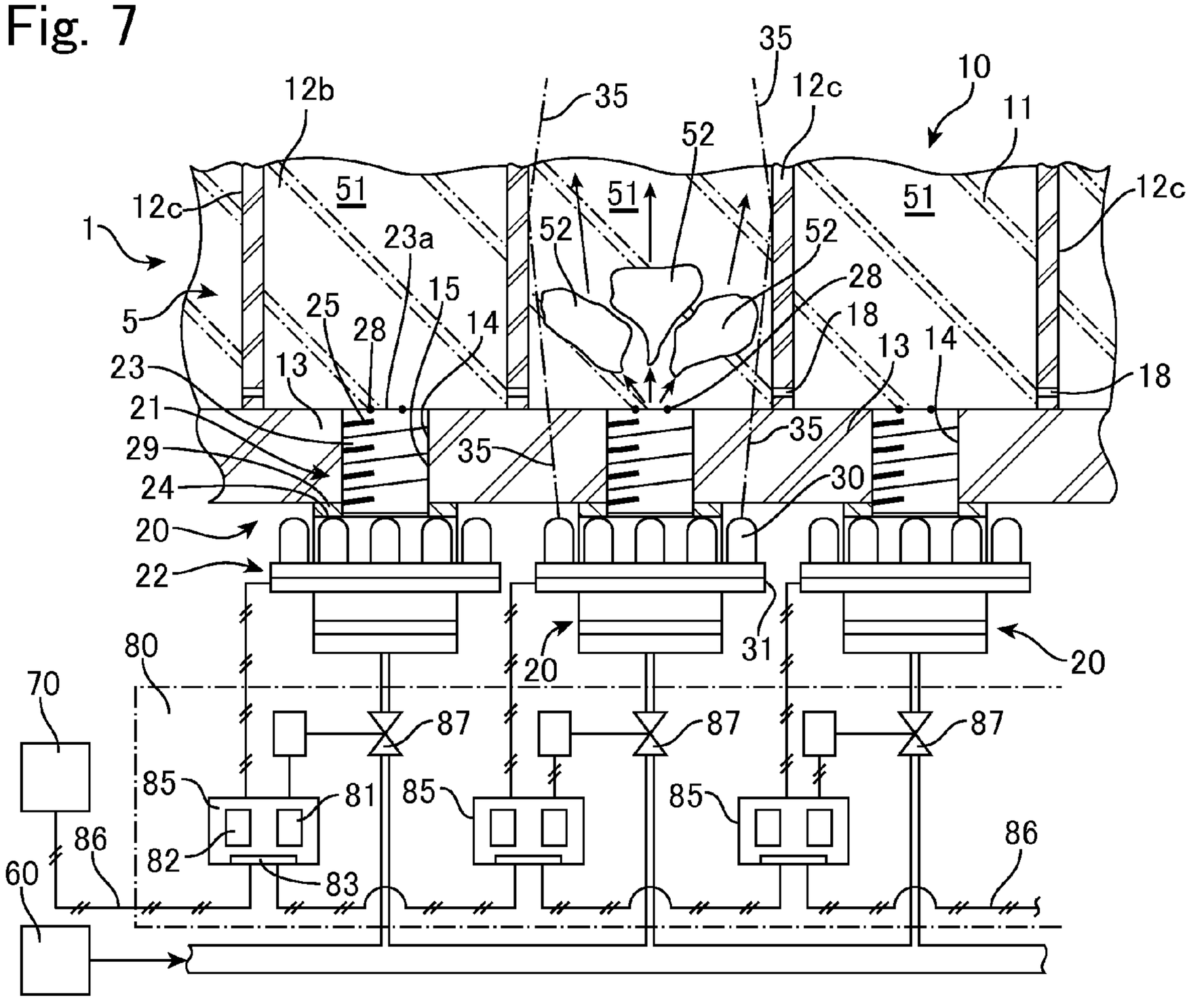

5
1
20
24
29
30
28
22
21
12c
12b
12c
11
13
14
10
25
23
23a
12a

Fig. 7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12c
10
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23a
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28
15
14
18
13
14
23
13
18
21
35
35
29
30
24
20
22
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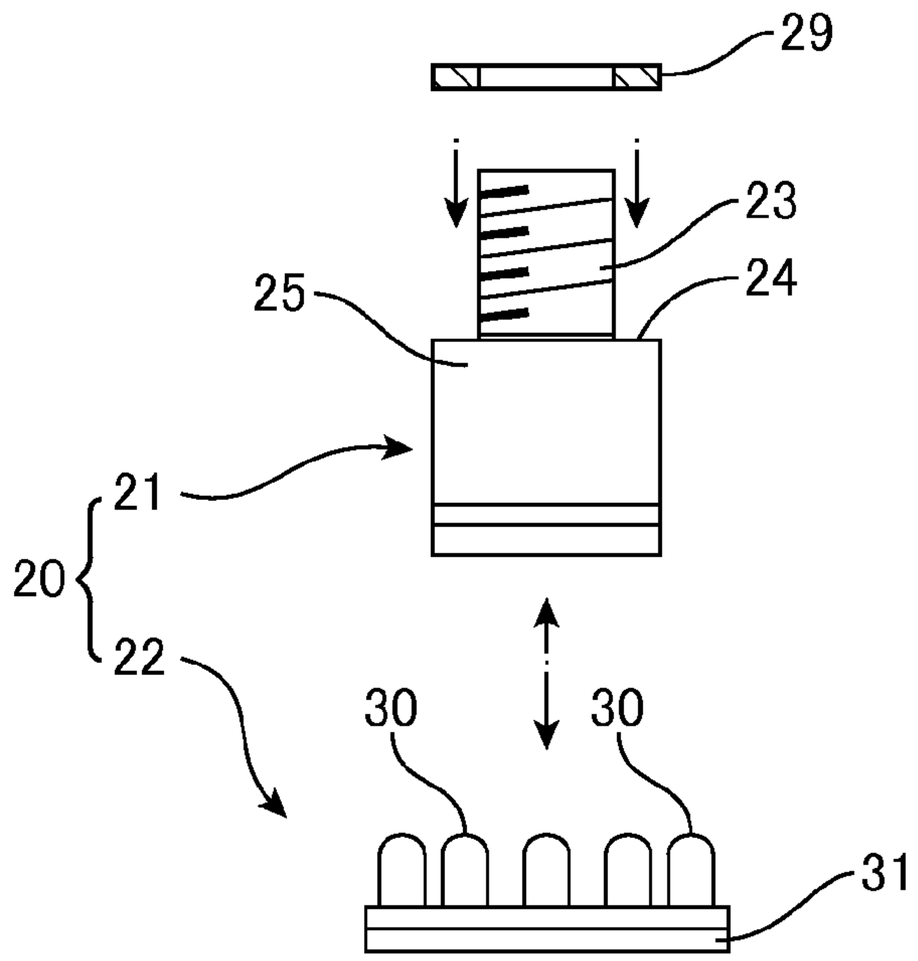
85
85
86
82
86
83
60

Fig. 8


29
23
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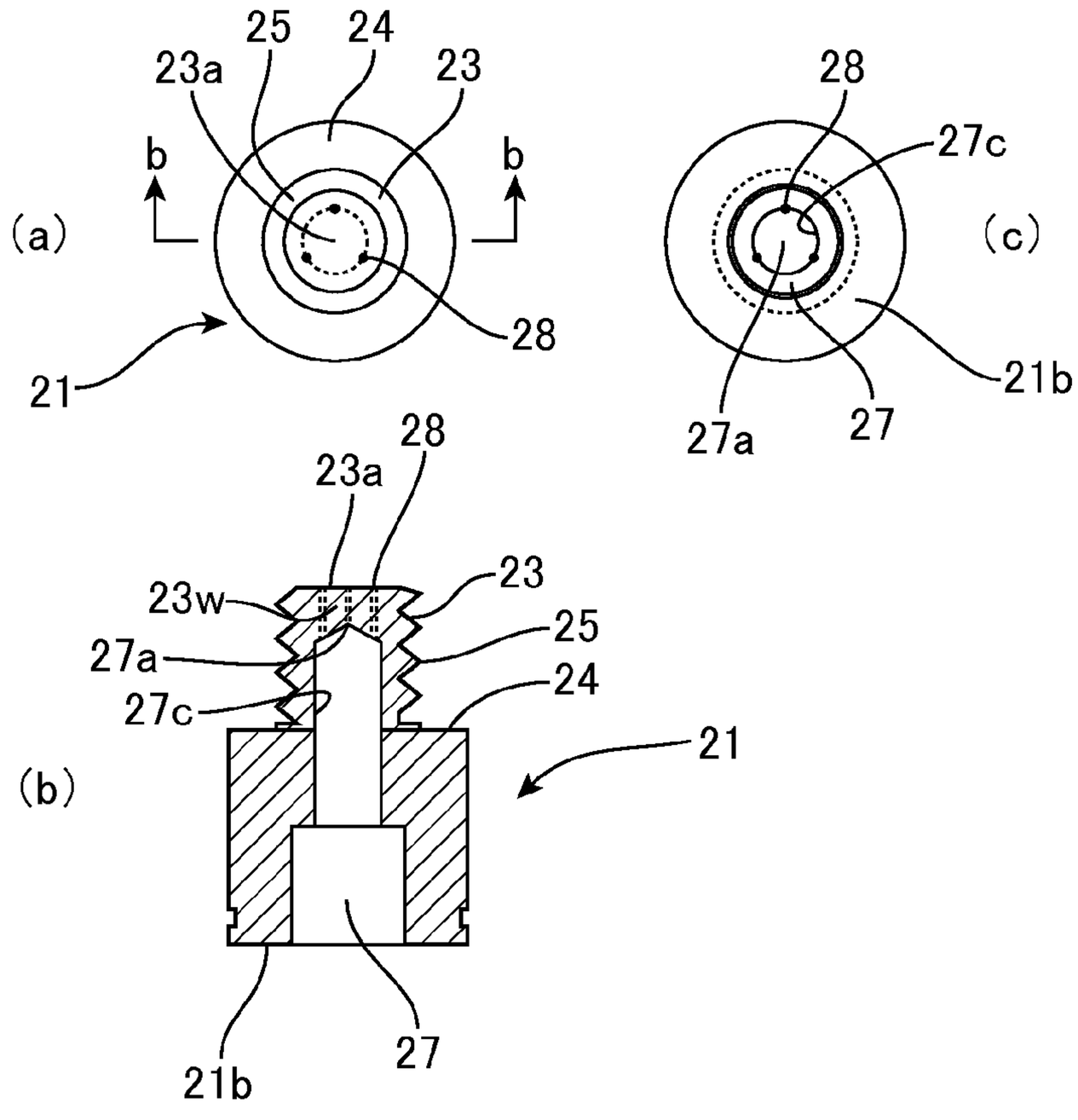
25
21
20
22
30
30
31

Fig. 9


25
24
23a
23
b
b
(a)
28
21
28
27c
(c)
21b
27a
27
23a
28
23
23w
25
27a
24
27c
21
(b)
21b
27

LIGHT GENERATING UNIT AND APPARATUS EQUIPPED WITH A PLURALITY OF LIGHT GENERATING UNITS

TECHNICAL FIELD

The present invention relates to a light generating unit.

BACKGROUND ART

Japanese Laid-Open Patent Publication No. 2004-264383 discloses the provision of a display apparatus capable of reproducing beautiful images with uniformity and clarity using bubbles. The display apparatus disclosed in this publication has a plurality of elongated containers disposed side by side with their lengths directed vertically, the elongated containers contain water, and an air feed pipe corresponding to each elongated container for feeding air from the bottom of the elongated container includes: a solenoid valve switched on and off under the control of a controller for feeding and stopping the feeding of air supplied from an air pump; a flow controller capable of maintaining the flow rate of the air to be fed at a predetermined value; and a check valve, such elements being disposed in order in the direction of feed and an air stone being provided at the end thereof. Microbubbles are generated from a filter at substantially the outer circumference of the air stone and images are displayed using the bubbles.

DISCLOSURE OF THE INVENTION

There is demand for an apparatus capable of reproducing more beautiful and/or more colorful images using bubbles.

One aspect of the present invention is a light generating unit including: a transparent vessel that is elongated and contains a liquid; and a light-emitting/bubble producing unit (light-emitting and bubble producing unit) attached to a base portion of the vessel. The light-emitting/bubble producing unit includes a plurality of light-emitting elements disposed around inner surfaces of side walls of the vessel and a plurality of nozzles for discharging a gas that are disposed on an inside of the plurality of light-emitting elements. With this light generating unit, the side walls of the vessel can be illuminated with like of a single color or multiple colors outputted from the plurality of light-emitting elements of the light-emitting/bubble producing unit. It is also possible to guide the light from the plurality of light-emitting elements along the elongated vessel using reflection at the side walls of the vessel.

In addition, it is possible to scatter the light of a single color or multiple colors guided along the vessel using bubbles of gas discharged from the plurality of nozzles. Accordingly, in this light generating unit, it is possible to produce a variety of displays and representations using changes in the color of the side walls of the vessel, movement of the bubbles that observed thought the side walls, and also changes in light due to the movement of the bubbles.

In the light-emitting/bubble producing units, the plurality of light-emitting elements should preferably include light-emitting elements, typically LEDs, of various colors, for example R (red), G (green), and blue (B). By doing so, it is possible to output illumination light of multiple colors while controlling the color and time (timing). It is also possible to output illumination light of multiple colors while controlling the color and time (timing) according to another method, such as control in synchronization with a rotating color filter and a

light emitting from the plurality of light-emitting elements. In addition, by controlling the timing at which gas is discharged from the plurality of nozzles, it is possible to control the timing at which a plurality of bubbles are discharged from the light-emitting/bubble producing unit. This means that it is possible to produce a variety of representations and displays by changing the movement of bubbles and changing the illumination light along the elongated vessel of the light generating unit.

In this light generating unit, the vessel may include a base plate that is transparent and is provided with an opening in a center thereof, and the light-emitting/bubble producing unit may include a convex portion that is fitted into the opening of the base plate from below and a flange portion that seals the opening of the base plate at a circumference of the convex portion. The plurality of nozzles may be provided at the convex portion and the plurality of light-emitting elements may be disposed so as to face the base plate around a circumference of the flange portion. The light generating unit can be assembled by merely fitting or inserting the convex portion of the light-emitting/bubble producing unit into the base plate. It is also possible to detachably attach the light-emitting/bubble producing unit to the base plate, which facilitates maintenance of the light-emitting/bubble producing unit. By exchanging the light-emitting/bubble producing unit, it is also possible to output bubbles of a different size or with different movement by changing the diameters and arrangement of nozzles for discharging gas and/or to produce illumination light of a different balance of colors.

In addition, the light-emitting/bubble producing unit should preferably include a cylindrical cavity that passes through the flange portion and reaches the convex portion to form a partition wall at a front end of the convex portion, the plurality of nozzles being formed effectively in a direction in which an inner circumferential surface of the cylindrical cavity extends. It is possible to machine the channels that supply gas to the plurality of nozzles and the plurality of nozzles themselves from the flange portion side, which means that the light-emitting/bubble producing unit can be provided at low cost.

In addition, a front end of the cylindrical cavity should preferably be dome-shaped. Since the part at the front end of the cylindrical cavity that is connected to the plurality of nozzles has an overall swollen shape which facilitates the accumulation of gas, it is possible to stably produce bubbles from the gas discharged from the plurality of nozzles.

Another aspect of the present invention is an apparatus including: a light generating block in which a plurality of the light generating units described above are arranged; and a control unit controlling timing of coloration and bubble discharge of the respective light-emitting/bubble producing units of the plurality of light generating units. The vessels of the plurality of light-emitting elements may be arranged in the form of a straight pillar or a circular column, or twisted in a spiral to provide apparatuses with light-emitting blocks of a variety of forms.

A typical example of a light generating block has the plurality of light generating units arranged so that the vessels construct a wall and illuminates the respective vessels and the bubbles rising inside the vessels with light of various colors. It is also possible to display characters and images using bubbles that rise in the respective vessels and to use the light generating block as a display.

In a light generating block where vessels are disposed adjacently, one or more side walls of the vessels of the plurality of light generating units may also be used as side walls of the adjacent vessels. The light generating block should

preferably also include first through channels that pass through and fluidly connect adjacent vessels at base ends thereof and second through channels that pass through adjacent vessels at front ends thereof to fluidly connect regions containing the liquid. Since it is possible to use the adjacent vessels as through pipes, it is possible to suppress fluctuations in liquid pressure inside the vessels due to the formation and rising of the bubbles, and to suppress fluctuation in the velocity with which the bubbles rise. The initial introduction of the liquid into a plurality of vessels also becomes easier.

It is preferable for the cross-sectional area of each second through channel to be larger than the cross-sectional area of each first through channel. Since the fluctuations in pressure at the base portion where the bubbles are formed is large, by making the cross-sectional area of the first through channels relatively small, it is possible to lower the extent to which fluctuations in pressure at the base portion affect adjacent vessels.

In addition, the control unit should preferably include a plurality of light emission control units that respectively control coloration of the plurality of light-emitting/bubble producing units and a plurality of bubble discharge control units that respectively control bubble discharge by the plurality of light-emitting/bubble producing units, wherein the plurality of light emission control units and the plurality of bubble discharge control units are connected in a daisy chain by a DMX data link. DMX (DMX512-A, Asynchronous Serial Digital Data Transmission Standard for Controlling Lighting Equipment and Accessories) is a communication protocol mainly used to control stage lighting and performance appliances, and is capable of connecting a plurality of controlled appliances in a daisy chain. Accordingly, by using a controller that controls appliances according to DMX protocol, it is possible to control coloration and bubble discharge by the plurality of light-emitting/bubble producing units and to control the display or representation of the light generating block using a control system of a simple construction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a series of diagrams showing an overview of a display apparatus **1**, where FIG. **1**(*a*) is a front view, FIG. **1**(*b*) is a right-side view, and FIG. **1**(*c*) is a plan view.

FIG. **2** is a front view of the display apparatus **1** and shows a different example display.

FIG. **3** is a III-III cross-sectional view of the display apparatus **1** where the display apparatus **1** is sliced on a horizontal plane.

FIG. **4** is a IV-IV cross-sectional view of the display apparatus **1** where the display apparatus **1** is sliced on a vertical plane.

FIG. **5** is a V-V cross-sectional view of the display apparatus **1** where the display apparatus **1** is sliced on a vertical plane.

FIG. **6** is an enlarged view of a light-emitting/bubble producing unit when looking via a base plate of the display apparatus **1**.

FIG. **7** is a diagram showing, by way of a partial cross-sectional view, how a light-emitting/bubble producing unit is attached to the base plate.

FIG. **8** is an exploded view of a light-emitting/bubble producing unit.

FIG. **9** is a series of diagrams showing the construction of a bubble producing unit of the light-emitting/bubble producing unit, where FIG. **9**(*a*) is a plan view of the bubble producing unit, FIG. **9**(*b*) is a cross-sectional view of the bubble producing unit, and FIG. **9**(*c*) is a bottom view of the bubble producing unit.

DETAIL DESCRIPTION

FIG. **1** shows an overview of a display apparatus that is one embodiment of the present invention. FIG. **1**(*a*) is a front view of a display apparatus **1**, FIG. **1**(*b*) is a right-side view of the display apparatus **1**, and FIG. **1**(*c*) is a plan view of the display apparatus **1**. The display apparatus **1** includes a light generating block (lighting block, light-emitting block) **5**, in which a plurality of light generating units (lighting units, light-emitting units) **10** are aligned so as to form a wall surface **6**, and a base **7** that supports the light generating block **5**. The plurality of light generating units (light-emitting units) **10** each includes an elongated vessel (container) **11**. Light-emitting/bubble producing units corresponding to the respective light generating units **10** are housed in the base **7**. The individual light-emitting/bubble producing units illuminate the vessels **11** of the light generating units **10** with multiple colors and form bubbles **52** by releasing gas (typically air) into a liquid (typically water) **51** contained inside the vessels **11**. The upper end **5***a* of the light generating block **5** is covered with a cover **8** and a discharge outlet **8***a* is provided for releasing air that has risen as bubbles inside the vessels **11** of the plurality of light generating units **10** to the outside atmosphere.

The vessel **11** of a typical light generating unit **10** is surrounded in four directions by side walls **12***a* and **12***b* at the front and back that are made of transparent acrylic and side walls **12***c* that form partitions and has a space whose cross-section in the horizontal direction is rectangular formed inside, with such space extending in the vertical direction. Accordingly, the vessel **11** is in the form of an elongated tube (square tube) and is capable of containing the liquid **51** inside. The light generating block **5** of the display apparatus **1** includes sixteen vessels **11** that are adjacently disposed in a row, and the side walls (partition walls) **12***c* of adjacent vessels **11** are composed of shared acrylic boards. Accordingly, in the light generating block **5**, the plurality of vessels **11** are formed by partitioning a wall-like water tank using a plurality of acrylic boards. As one example of the size of the respective vessels **11**, the length in the vertical direction is 1000 mm and the internal space that contains liquid has a square cross section with 34 mm edges. The front and rear walls (side walls) **12***a* and **12***b* of the light-emitting block **5** upon which water pressure acts and the left and right side walls **12***d* are transparent acrylic boards that are 5 to 6 mm thick, and the side walls **12***c* that form partitions are transparent acrylic boards that are 3 to 4 mm thick.

The various values given above are merely examples and the light generating block (lighting block, light-emitting block) **5** may be constructed of 17 or more or 15 or fewer vessels **11**. The size of the vessels **11** is also not limited to the size given above. Also, by using a plurality of light generating blocks **5** and/or a plurality of display apparatuses **1**, it is also possible to construct an even larger wall surface. So long as the material that constructs the side walls **12***a* to **12***d* is transparent or translucent, such material is not limited to acrylic boards and may be plate glass. To suppress adhesion of the bubbles to the inner surfaces of the vessels **11** and to improve rinsing, it is also effective for an aqueous solution that includes a small amount of a constituent such as a surfactant to be contained as the liquid **51**.

In the display apparatus **1** by connecting an air source, for example a compressor **60**, that supplies gas for forming the

bubbles **52** and a control console **70** that supplies signals for controlling the display apparatus **1** and the power used for illumination, the light generating block **5** is capable of a variety of performances according to the bubbles **52** and the color of the illumination light. For example, in FIG. **1**, by continuously introducing the bubbles **52** into all of the vessels **11** of the light generating block **5** and illuminating the inner surfaces of the vessels **11** with light of various colors, it is possible to use the lighting block **5** as a wall surface that lights up in the colors of the rainbow.

Also, as shown in FIG. **2**, by controlling the timing and amount of bubbles **52** introduced into the respective vessels **11**, it is possible to draw an image or characters that light up in one or many colors on the lighting block **5**.

FIG. **3** to FIG. **7** show the construction of the display apparatus **1** in more detail by way of cross-sectional views and enlargements. FIG. **3** is a cross-sectional view where the light generating block **5** has been sliced on a horizontal plane so that a base plate **13** that constructs a base ("base end" or "bottom plate") of the vessel **11** of each light generating unit **10** that constructs the lighting block **5** can be seen. The base plates **13** are also transparent acrylic boards and have openings **14** formed in the center thereof.

FIG. **4** is a cross-sectional view where the light generating block **5** and the base **7** have been sliced in the vertical direction at a position in the width direction of the light generating block **5**. The light-emitting/bubble producing units **20** of the respective light generating units **10** are housed in the base **7** and the respective light-emitting/bubble producing units **20** are attached from below to the openings **14** of the base plates **13** of the light generating units **10**. A control unit **80** for controlling coloration and bubble production timing of the respective light-emitting/bubble producing units **20** of the plurality of light generating units **10** is also housed inside the base **7**.

FIG. **5** is a cross-sectional view where the light generating block **5** and the base **7** have been sliced on a vertical plane at a position in the thickness direction (a direction perpendicular to the width direction) of the light generating block **5**. In partition side walls **12***c* between adjacent vessels **11**, out of the side walls that construct the vessels **11** of the respective light generating units **10**, first through channels **18** and second through channels **19** that fluidly connect the adjacent vessels **11** are formed. The first through channels **18** are provided at the base end of each vessel **11**, that is, directly above the base plates **13**. The second through channels **19** are provided in the vicinity of the upper ends **17** of the vessels **11**, at positions near the upper limit for filling the liquid **51**. In the display apparatus **1**, the second through channels **19** are holes with a diameter of around 14 to 16 mm and the first through channels **18** are holes with a diameter of around 4 to 6 mm.

These through channels **18** and **19** suppress pressure fluctuations in the liquid **51** inside the vessels **11**. For example, the volume of the liquid **51** will increase when bubbles **52** are discharged into a vessel (cell) **11**. For this reason, the second through channels **19** are provided at the upper end of the vessels **11** so that the liquid **51** flows into the adjacent vessels **11**. The first through channels **18** at the lower end are effective in dispersing the pressure applied to each vessel **11** and keeping such pressure uniform. The first through channels **18** at the lower end also connect the plurality of vessels **11** for liquids to pass at the lower end. This means that the through channels **18** are effective when introducing and discharging the liquid **51** into or from the plurality of vessels **11** that construct the lighting block **5**. However, there is the possibility that the pressure of a neighboring vessel **11** will rapidly fluctuate when bubbles **52** are discharged. That is, if the pressure when the bubbles **52** are produced is transmitted to adjacent vessels **11** via the first through channels **18**, this can cause disruption to the pattern of the bubbles **52** rising inside the adjacent vessels **11**. For this reason, the diameter (cross-sectional area) of the first through channels **18** at the lower end is reduced to suppress the propagation velocity of fluctuations in pressure.

Via these through channels **18** and **19**, circulation of the liquid **51** in the up-down direction inside a given vessel **11** is maintained via the adjacent vessels **11**, so that pressure fluctuations inside each vessel **11** are suppressed. Accordingly, even when a large amount of bubbles **52** are discharged into a vessel **11**, fluctuations in the internal pressure of the vessel **11** are suppressed and it is possible for the bubbles **52** to rise smoothly along the vessel **11** at a uniform velocity.

FIG. **6** shows the light-emitting/bubble producing units (light-emitting and bubble producing units) **20** when looking from above through the transparent base plates (bottom plates) **13** of the vessels **11**. FIG. **7** shows how the light-emitting/bubble producing units **20** are attached to the base plates **13** by way of a partial cross-sectional view. FIG. **8** shows a light-emitting/bubble producing unit **20** split into a bubble producing unit **21** and a light emitting unit **22**.

Each light-emitting/bubble producing unit **20** includes a bubble producing part **21** and a light emitting part **22** attached to the circumference of the bubble producing part **21**. The bubble producing unit **21** is a cylindrical plug formed of resin such as polycarbonate, although another resin material may be used. Although the bubble producing unit **21** is cylindrical as a whole, the central part of the bubble producing unit **21** is formed in a step and a convex portion **23** that protrudes upward relative to the outer circumference **24** is provided. A male screw thread **25** is also formed on the outer circumference of the convex portion **23**. Female screw threads **15** corresponding to the male screw threads **25** of the bubble producing units **21** are formed on the openings **14** in the centers of the base plates **13**. This means that by fitting (screwing) the convex portion **23** of a bubble producing unit **21** into the opening **14** of a base plate **13** from below, it is possible to attach the light-emitting/bubble producing unit **20** to the base plate **13**. Conversely, it is also possible to detach the light-emitting/bubble producing unit **20** from the base plate **13**

When the convex portion **23** of the light-emitting/bubble producing unit **20** is fitted into the base plate **13** from below, the circumference (flange portion) **24** of the convex portion **23** of the bubble producing unit **21** becomes tightly attached to the lower surface of the base plate **13** with packing (an O ring) **29** in between. Accordingly, by attaching the light-emitting/bubble producing unit **20** to the opening **14** of the base plate **13**, the opening **14** can be sealed by the convex portion **23** of the bubble producing unit **21** and the flange portion **24**. This means that by merely attaching the light-emitting/bubble producing unit **20** from below the base plate **13**, attachment of the light-emitting/bubble producing unit **20** is completed. In addition, it is extremely easy to make the upper end (the upper end of the convex portion **23**) **23***a* of the bubble producing unit **21** level with the upper surface of the base plate **13**.

Three gas discharging nozzles **28** are formed on the upper end (upper surface) **23***a* of the convex portion **23**. By discharging air from the respective nozzles **28**, it is possible to introduce a plurality of bubbles **52** into the inside of the vessel **11**. Accordingly, in the light generating unit **10**, it is possible to allow the bubbles **52** to rise from above the base plate **13**.

The light emitting unit **22** includes a plurality of LEDs **30** and a substrate **31** that supports and also electrically connects

the LEDs **30**. The substrate **31** is around the same size as the cross-section of the vessel **11**, that is, in the present embodiment a square with 34 mm edges or a circular disc inscribed therein. The plurality of LEDs **30** are arranged in a ring around the circumference of the substrate **31** and an opening through which the bubble producing unit **21** passes is provided in the center of the substrate **31**. Accordingly, when the light-emitting/bubble producing unit **20** is assembled from the light emitting unit **22** and the bubble producing unit **21**, the plurality of LEDs **30** become disposed around the circumference of the convex portion **23** equipped with the nozzles **28**. In addition, when the light-emitting/bubble producing unit **20** is attached to the opening **14** of the base plate **13**, the plurality of LEDs **30** are disposed around the inner surfaces of the side walls **12***a*, **12***b*, and **12***c* of the vessel **11**.

The plurality of LEDs **30** include a plurality of red (R) LEDs, a plurality of green (G) LEDs, and a plurality of blue (B) LEDs, and are attached to the substrate **31** so as to be positioned around the inner surfaces of the side walls **12***a*, **12***b*, and **12***c* with an appropriate balance. That is, the numbers of LEDs (light-emitting elements) **30** that emit light of the respective colors R, G and B are selected based on the color balance and LEDs **30** of the respective colors are disposed so as to be able to illuminate the side walls **12***a*, **12***b*, and **12***c* with a favorable balance.

The refractive index of the transparent side walls **12***a*, **12***b*, **12***c*, and **12***d* (hereinafter represented by the expression "the side walls **12***a*") made of glass or acrylic is typically higher than the refractive index of the liquid (typically water or an aqueous solution) **51** contained in the vessels **11**. As examples, the refractive index of water is around 1.33 and the refractive index of acrylic is around 1.45. Accordingly, the light **35** that illuminates the liquid **51** inside the vessels **11** is not totally reflected by the inner surfaces of the side walls **12***a*. However, by increasing the angle of incidence of the illumination light **35** on the inner surfaces of the side walls **12***a*, it is possible to increase the reflectance at the inner surfaces of the side walls **12***a*. It is also possible to color the side walls **12***a* using light that has leaked from the side walls **12***a*, which means that the illumination light **35** can be efficiently guided along the elongated vessels **11**.

As shown in FIG. **7**, in the light generating unit **10**, when a light-emitting/bubble producing unit **20** is attached to the base plate **13** of a vessel **11**, the plurality of LEDs (light-emitting elements) **30** become disposed around the inner surfaces of the side walls **12***a*. Accordingly, illumination light **35** from the plurality of LEDs **30** passes through the transparent base plate **13** and lights or irradiates on the inner surfaces of the side walls **12***a* with a large angle of incidence. This means that the side walls **12***a* are illuminated by the illumination light **35** from the base plate **13** and that the illumination light **35** is efficiently guided upward along the elongated vessel **11**.

In the light-emitting/bubble producing unit **20**, the plurality of nozzles **28** are disposed on the inside of the plurality of LEDs **30**. When gas is discharged from the plurality of nozzles **28**, a plurality of bubbles **52** are formed at substantially the same time. Since this plurality of bubbles **52** have a volume that increases rapidly, the bubbles **52** do not gather in the center of the vessel **11** and instead rise in a state where the bubbles **52** extend to the vicinity of the side walls **12***a*. In addition, the refractive index of the gas (typically air) that forms the bubbles **52** is 1.0, which is lower than the refractive index of the liquid (water or aqueous solution) **51**. Accordingly, depending on the angle of incidence of the illumination light **35** on the surfaces of the bubbles **52**, the bubbles **52** totally reflect the illumination light **35**. In this way, the plurality of bubbles **52** discharged from the light-emitting/bubble producing units **20** are outputted in the same way from the light-emitting/bubble producing units **20**, proceed along the elongated vessels **11**, and act as light scatterers that effectively reflect the illumination light **35** in various directions. This means that with the illumination light **35**, it is possible to illuminate the bubbles **52** that rise up the vessels **11** from the periphery of the bubbles **52**. It is also possible to have the bubbles **52** rise along the elongated vessels **11** while light is being shone upon the bubbles **52**.

In the plurality of light generating units **10** that construct the lighting block **5** of the display apparatus **1**, it is possible to independently control the output timing of the bubbles **52** that rise up the vessels **11** of the light generating units **10** and the color, intensity, and timing of the illumination light **35** that illuminates the vessels **11** and the bubbles **52**. Accordingly, in the light generating block **5**, the respective displays of the plurality of light generating units **10** can be independently and variously changed using the bubbles **52** and the illumination light **35**. This means it is possible to display (represent) a wide variety of colors, light, designs, images, and the like using the lighting block **5**.

The control unit **80** that controls the coloration and bubble discharge timings of the light-emitting/bubble producing units **20** includes control boxes **85** that control the respective light-emitting/bubble producing units **20**. The respective control boxes **85** include a light emission control unit **82** that controls coloration of the corresponding light-emitting/bubble producing unit **20**, a bubble discharge control unit **81** that controls the bubble discharge of the corresponding light-emitting/bubble producing unit **20**, and a connector **83** that is compatible with DMX standard. Accordingly, the plurality of control boxes **85** are capable of being connected in a daisy chain by a link cable **86** that is compatible with DMX standard and that it is possible to connect the light emission control unit **82** and the bubble discharge control unit **81** housed in each control box **85** using a DMX data link.

Each light emission control unit **82** is connected to the substrate **31** of a light emitting unit **22**, supplies power to the respective LEDs **30** of the light emitting unit **22**, and causes the respective LEDs **30** to light up at desired timing. Accordingly, by using the light emission control units **82**, it is possible to control the color, timing, and intensity with which the respective vessels **11** are illuminated. Each bubble discharge control unit **81** is connected to a control valve **87** (typically a solenoid valve) that is capable of turning compressed air, which is supplied from the compressor **60**, to a bubble producing unit **21** on and off. Accordingly, the control valve **87** is switched on and off at desired timing by the bubble discharge control unit **81**, and by controlling the amount and timing of the air outputted from the nozzles **28** of the bubble producing unit **21**, it is possible to control the size and timing of the bubbles **52** that rise inside a vessel **11**.

The link cable **86** is connected to the illumination control console **70** that is compatible with DMX standard. Accordingly, it is possible to freely control the timing at which bubbles **52** are outputted in the respective light generating units **10** that construct the light generating block **5** and the color, timing, intensity, and the like of the light that illuminates each light generating unit **10** using a conventional illumination control console **70** and to also program a pattern including such timings and intensities. This means that it is possible to control the display of the light-emitting block **5** extremely easily and to display a variety of designs, information, images, and the like on the light-emitting block **5**.

FIG. **9** shows the construction of the bubble producing unit **21** of a light-emitting/bubble producing unit **20**. As shown by

the cross-sectional view in FIG. **9**(*b*), the bubble producing unit **21** includes a cylindrical cavity **27** that passes through the flange portion **24** to reach the convex portion **23** and forms a partition wall **23***w* at the front end **23***a* of the convex portion **23**. As shown in FIG. **9**(*a*), the three nozzles **28** are formed at intervals of an equal angle so as to pass through the partition wall **23***w* in the direction in which the inner circumferential surface **27***c* of the cylindrical cavity **27** extends. Accordingly, the nozzles **28** are formed effectively or substantially along the inner circumferential surface **27***c* of the cavity **27** in the direction in which the inner circumferential surface **27***c* extends. For this reason, as shown in FIG. **9**(*c*), the three nozzles **28** can be formed by boring holes through the cavity **27** from the rear surface side **21***b* of the bubble producing unit **21** and the entire hole boring process for the bubble producing unit **21** including the cavity **27** can be carried out from the rear surface side **21***b*. Accordingly, the bubble producing unit **21** can be provided at low cost.

In addition, the front end **27***a* of the cylindrical cavity **27** is machined into a dome shape with the nozzles **28** extending from the circumference of the dome. Accordingly, air will accumulate at the bases of the respective nozzles **28** and air can be discharged substantially uniformly from the three nozzles **28**. This means that even though an air stone or the like is not used, it is still possible to form a plurality of bubbles **52** of a desired size inside a vessel **11** substantially uniformly using the bubble producing unit **21** which is manufactured from resin.

In this way, the display apparatus **1** is capable of displaying information, such as images and characters, on the lighting block **5** through combinations of the illumination light **35** and the bubbles **52** that rise inside each of the plurality of lighting units **10**. The display is not limited to images and characters and the light generating block is capable of a variety of displays, representations and performances using the bubbles **52** and the illumination light **35**. This means that the display apparatus **1** can be used for a wide variety of purposes such as theater equipment, lighting, an image display device, an information display device, and a message display device.

Although a plurality of light generating units **10** are arranged in a line so as to form a single wall surface in the display apparatus **1**, it is also possible to arrange a plurality of light generating units **10** so as to form a pillar or a cylindrical column. It is also possible to construct a light generating block **5** in the form of a wall by arranging a plurality of light generating units **10** in a wavy pattern. It is also possible to construct a light generating block **5** in the form of a pillar by bundling a plurality of light generating units **10** in a spiral. However, the form of the display apparatus **1** is not limited to the examples described above.

Also, although LEDs are used as the light-emitting elements of the light emitting unit **22** described above, it is also possible to use other light-emitting elements, such as organic EL or semiconductor lasers, or another light-emitting device. Although a DMX link that is often used at present to control lighting is favorable as the control system of the display apparatus **1**, the data link method is not limited to DMX and it is possible to use a wired or wireless LAN or a communication-type data link that uses a different protocol.

The invention claimed is:

1. A light generating block comprising a plurality of light generating units, each of the plurality of light generating units includes:

a transparent vessel that is elongated and contains a liquid; and

a light-emitting/bubble producing unit attached to a base portion of the vessel,

wherein the plurality of light generating units are arranged so that vessels of the plurality of light generating units construct a wall, and

the light-emitting/bubble producing unit includes:

a convex portion that is fitted into an opening of a center of a transparent base plate of each of the vessels from below;

a flange portion that seals the opening of the base plate in a circumference of the convex portion;

a plurality of light-emitting elements disposed around a circumference of the flange portion so as to face the base plate and disposed around inner surfaces of side walls of each of the vessels when the convex portion is fitted into the opening of the base plate; and

a plurality of nozzles for discharging a gas that are provided at the convex portion and disposed on an inside of the plurality of light-emitting elements, and

wherein, by the light-emitting/bubble producing unit fitted on each of the vessels, bubbles are introduced to each of the vessels and bubbles rising in each of the vessels are illuminated on a vessel-by-vessel basis.

2. The light generating block according to claim **1**,

wherein the light-emitting/bubble producing unit includes a cylindrical cavity that passes through the flange portion and reaches the convex portion to form a partition wall at a front end of the convex portion, the plurality of nozzles being formed substantially in a direction in which an inner circumferential surface of the cylindrical cavity extends at intervals of an equal angle.

3. The light generating block according to claim **2**,

wherein a front end of the cylindrical cavity is dome-shaped.

4. The light generating block according to claim **1**,

wherein the plurality of light-emitting elements include a plurality of LEDs that output light of different colors.

5. An apparatus comprising:

a light generating block according to claim **1**; and

a control unit controlling timing of coloration and bubble discharge of respective light-emitting/bubble producing units of the plurality of light generating units.

6. The apparatus according to claim **5**,

wherein in the light generating block, one or more side walls of the vessels of the plurality of light generating units are also used as side walls of adjacent vessels.

7. The apparatus according to claim **5**,

wherein the light generating block includes first through channels that pass through and fluidly connect adjacent vessels at base ends thereof and second through channels that pass through adjacent vessels at front ends thereof to fluidly connect regions containing liquid.

8. The apparatus according to claim **7**,

wherein a cross-sectional area of each second through channel is larger than a cross-sectional area of each first through channel.

9. The apparatus according to claim **5**,

wherein the control unit includes a plurality of light emission control units that respectively control coloration of the light-emitting/bubble producing units and a plurality of bubble discharge control units that respectively control bubble discharge by the light-emitting/bubble producing units,

wherein the plurality of light emission control units and the plurality of bubble discharge control units are connected in a daisy chain by a DMX data link.

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